Space Weather Technical Forecast

Issued on Tuesday, 17 January 2023 at 00:39 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Further R1/R2 Radio Blackouts Likely. Risk of G1/Minor Geomagnetic Storm rising from midweek.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity became Low through the UTC day of Monday 16 January, with X-ray flares recorded at GOES16 peaking with a C8.7 at 16/0923UTC. This flare emanated from AR3182, which has continued its recent trend of supplying flares despite an apparent reduction in complexity and while undergoing areal decay, becoming a Cro/Beta with fading trailer spots over the 24 hours. This group was one of nine numbered sunspot regions on the disc at present, with a potential new unnumbered region also developing in the northeast as a Bxo/Beta.

Probably the main development in terms of sunspot regions on the disc in the past day has been the areal growth and trailer spot proliferation in AR3190 in the southeast, with this group now exceeding 1000mhs owing to its large leading penumbral spot, with this group classified as a Eki/Beta-Gamma-Delta by the period's end. The Mt Wilson delta spot candidates within this spot are relatively tenuous, as is the case with AR3186 in the northeast, with this latter group showing less congestion in its intermediate portion with time. All of the groups on the disc were at least bipolar in nature, with many Zurich D- E- or F-groups, however there was a notable relative lack of activity compared to the recent past, perhaps because of these spot groups' maturity and/or slight decaying tendencies.

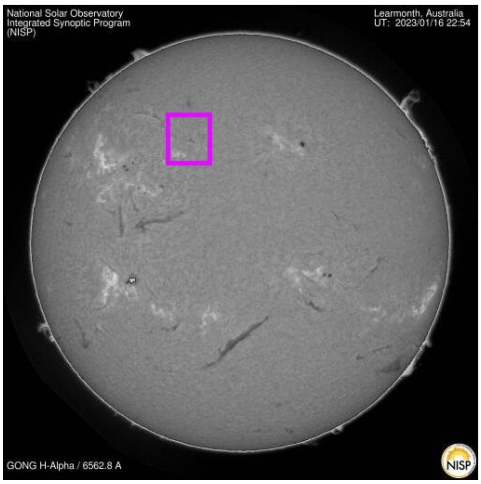

Figure 0: Possible filament eruption visible on H-Alpha imagery in the final hour of the UTC day of Monday 16 January. There is as yet no confirmatory coronagraph imagery to show any ICME, with this awaited.

No new Earth-directed CMEs have been observed in available coronagraph imagery. At the very end of the period, around 16/2330UTC a small filament disappeared from the vicinity of the new unnumbered sunspot in the northeast. At the time of writing it is not yet clear as to whether this

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feature left the immediate solar environment or not, but this will be watched for. There are otherwise numerous mostly small filaments on the disc at present, however the largest currently straddles the solar meridian near 30S and is probably the main monitoring in this vein.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by DSCOVR, showed possible waning CME effects. The culprit is not certain, but may be related to the 11 January CME which was possibly misdiagnosed as arriving earlier over the UTC weekend.

The solar wind speed showed an initial slight rise to 530km/s before gradually waning over much of the rest of the period to approach 450km/s. The solar wind density showed an early peak near 25ppcc before returning to long term background in single figures ppcc into the UTC evening. The IMF behaved relatively erratically, with an initial peak near 8nT later repeating around the middle of the UTC day, before undergoing a more lasting reduction with time. The north-south component was less unsettled, varying between +8 and -5nT and showing an overall trend from co-alignment with Earth's field to start the period, through anti-alignment - this, save for a blip back into positive Bz territory with the second IMF peak. The earlier trend then resumed in a vague sinusoid that may be attributable to the magnetic cloud of the ongoing CME. The phi angle was mainly positive (away from the Sun) for the duration.

The net effect of the above solar wind measures was for provisionally Quiet to Active Kp indices, with an erratic tendency overall, and peaking at Kp '4o' in the 00-03UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 has been at Background levels throughout.

High energy electron flux (greater than 2 MeV) showed a relative amplitude increase in its diurnal cycle versus weekend counts, although this still only peaked within Moderate flux near 550pfu. The 24-hour integrated electron fluence stayed below the Active threshold, but with an increasing trend, reaching 1.92e7 integrated pfu by 17/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to be Moderate, with a daily Slight Chance of reaching High levels. Although one of the more active regions departs the front side by midweek UTC, the sheer weight of current and expected eastern solar hemisphere arrivals should serve to compensate.

Solar Wind / Geomagnetic Activity: Solar winds are expected to soon revert to a slow regime, resulting in increasingly Quiet geomagnetic activity on Tuesday 17 January, perhaps the most reliably settled day of the forecast. Later on Wednesday 18 January, a fast wind of the order 450-500km/s is expected due to CH65/+ and/or CH66/+. Any CIR leading the fast wind may combine with the 14 January CME from the AR3182 twin M-flares later Wednesday or into Thursday 19 January, giving a Likely G1 before waning into the final day of the forecast.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is likely to remain at predominantly Background levels, but with a Slight Chance of enhancements to S1 or greater through the period due to a number of magnetically complex sunspot regions on the visible disc.

The high energy electron flux (greater than 2 MeV) is expected to continue at largely Moderate levels, possibly with a slight upward trend before midweek UTC, probably still insufficient for the corresponding electron fluence to breach Active (1e8 integrated pfu). A reduction in counts is then likely to follow midweek CME and fast wind activity for a time.

Figure 1. Solar Analysis Valid 16/1845UTC.

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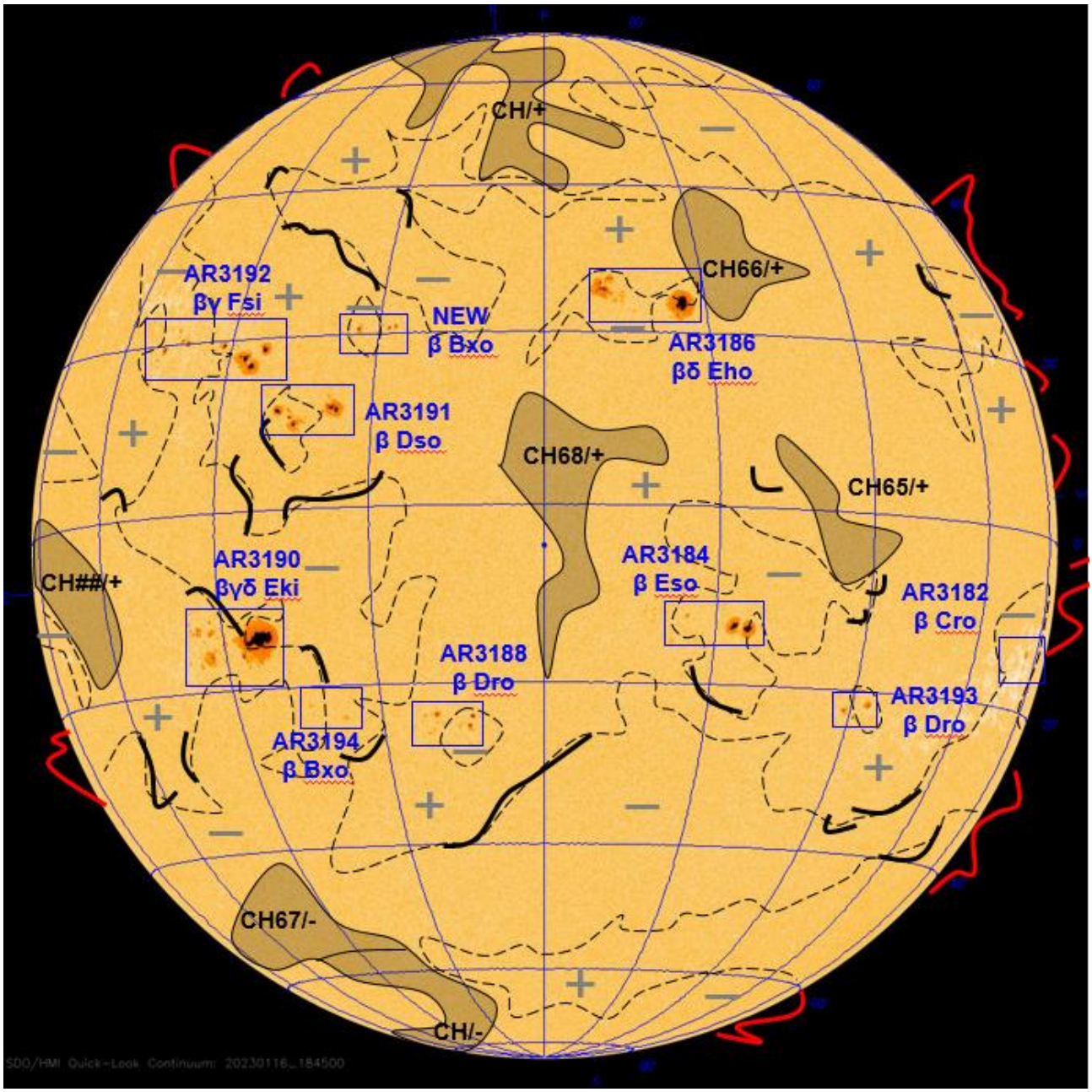
Met Office Space Weather Technical Forecast



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

This forecast period comprises an initial waning of residual 11 January CME effects, followed by the risk of concurrent arrival of a possible CIR leading CH65 and/or 66 later Wednesday with any 14 January CME influence.

As such, the most reliably Quiet period of the forecast should be the UTC day of Tuesday and perhaps the first half of Wednesday, with a Chance of Minor Geomagnetic Storm G1 midweek perhaps then becoming Likely on Thursday 19 January before Friday perhaps sees calmer conditions gradually restored.

CH65 and 66 are not particularly representative of their states on last pass, and as such persistence methods ought to be somewhat unsafe, however MOSWOC Enlil does suggest that a fast wind of up to around 500km/s may arrive, with any CIR perhaps bolstered by a glance from the 14 January twin-M-class CME from near AR3182. The phasing of all of these features is of lower confidence, but given the weight of contributors, at least some degree of enhanced geomagnetic activity is expected, and this is very likely to represent the peak for the four-day period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	40	60	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/0900UTC	Partial	AR3182	SW quadrant	400km/s	Around turn of UTC day 18 into 19 January	Probable hit, reasonable confidence.

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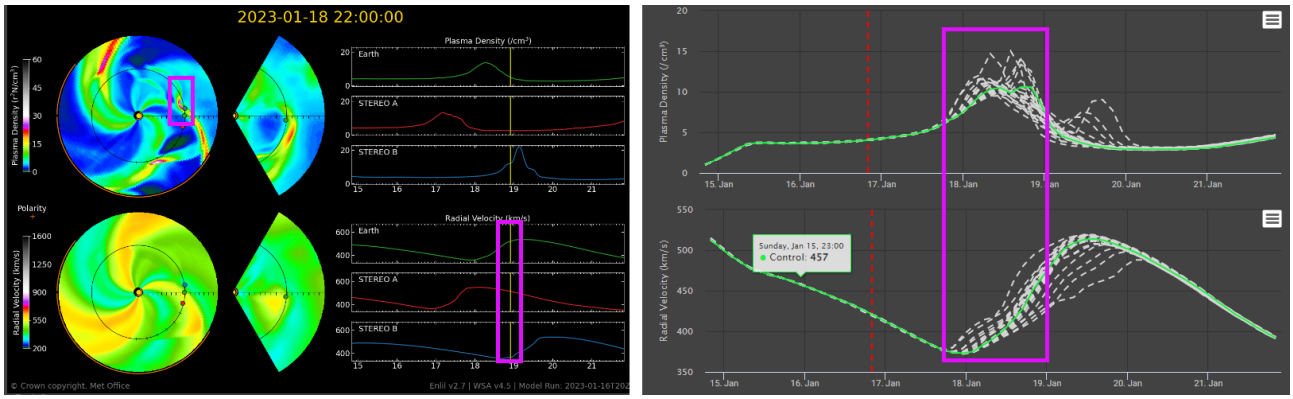
Figure 2: Latest MOSWOC Enlil run showing the 14 January CME as most likely arriving as a glancing blow around the turn of the UTC day Wednesday 18 into Thursday 19 January.



Radio Blackouts - X-Ray Flares:

Solar activity has become Low through the UTC of Monday 16 January. This is perhaps somewhat surprising given the complex and congested solar disc, however it is likely to be a measure of the constituent spot groups' maturity and slowing growth trends (with the main exception of AR3190 in the southeast).

Sunspot region AR3182 should rotate from the Earth-facing side by midweek UTC, however far-side soundings suggest further regions are to be expected on the opposite horizon, probably acting to maintain a Likely daily risk of M-class flares, although this has been slightly revised downwards given the quiescent X-ray flux trace and the slight decrease in the 10.7cm flux versus the UTC weekend peak.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	70	70	70	70
Very Active	R3 to R5 X Class	No	10	10	10	10

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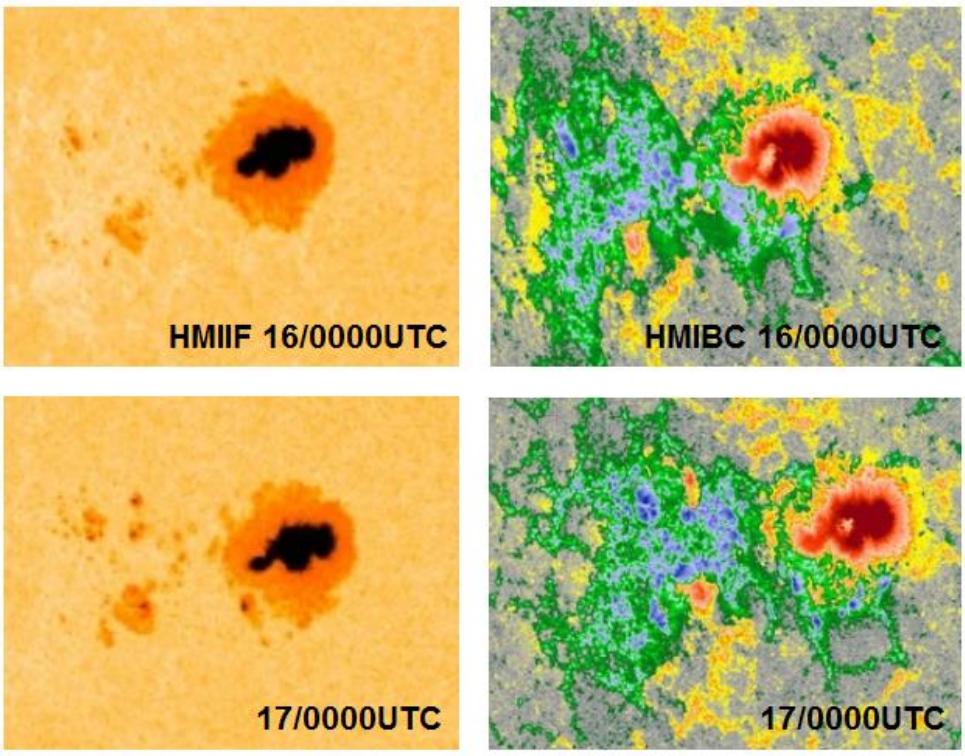
Figure 3: HMIIF and HIMBC imagery of the most-changed sunspot region in the past 24 hours, AR3190 in the southeast. Despite this growth, no significant flares were produced in the past 24 hours.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently at background levels.

While no recent S1+ events have been observed at GEO, the sheer number of both front and far-sided complex groups dictates an elevated risk. While the relative contribution to risk will decrease through the UTC working week for Ex-AR3181 and eventually (by then Ex-)AR3182, the weight of sunspot regions in the eastern solar hemisphere will increasingly bring itself to bear, resulting in a relatively constant Slight Chance of S1+ through the four days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):

High energy electron flux is oscillating between normal background and Moderate levels as part of the normal diurnal variation. The recent fast wind from CH62/- and effects from the recent CME are continuing to tail off, but have yet to manifest in any increased magnitude oscillation. However it is more likely than not that it will elicit some form of upward reaction in the next couple of days. The degree to which this occurs will most likely prove insufficient for 24-hour Active fluence to be realised, given the modest duration and intensity of the fast wind.

Persistence methods are not considered useful in the period given the apparent lack of similarity of the current disc with last rotation, as well as the presence of CMEs, however REFM is in agreement in the persistence of a sub-Active trend.

All considered, there is a slightly upward trend possible in flux and fluence in the immediate term, as recently seen, probably saturating within 24 hours before increased geomagnetic activity likely acts to temporarily suppress electron counts at GEO from later on Wednesday 18 January.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^{8}$**	No	20	30	10	10
Very Active	**≥ 2 MeV ≥ $1x10^{9}$**	No	1	1	1	1

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